SYNOPSIS OF

MONKEY ON A HOT TIN ROOF:

ECOLOGICAL AND BEHAVIOURAL ADAPTATIONS OF LION-TAILED MACAQUES TO A RAINFOREST-ANTHROPOGENIC HABITAT MATRIX IN THE WESTERN GHATS MOUNTAINS OF SOUTHERN INDIA

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Nonhuman populations and individuals existing outside protected areas often face increasing human-induced pressures, including direct interactions with humans. These interactions are escalating globally, and it is crucial to understand them in order to aid the management and conservation of these, often-threatened, species. Nonhuman primates (henceforth primates) are amongst the many taxa known to have direct, often detrimental, interactions with humans in such altered habitats. Some of these species, however, tend to be highly adaptable, particularly in anthropogenic situations; certain macaques, for example, are now commensal with humans across the Indian subcontinent. A rather unique case of human–primate interaction in our country is that of the rainforest-specialist lion-tailed macaque *Macaca silenus*, resident, amongst other locations, on the Valparai plateau of the Western Ghats mountains in Tamil Nadu state, southern India.

The lion-tailed macaque is an endangered species, endemic to the Western Ghats mountains of southern India. Whilst generally being classified as an elusive habitat-specialist, some populations have, over the past decade, begun exiting their rainforest habitat to explore and utilise human habitations. These unique populations, therefore, defy previously postulated predictions about the species' ecological and behavioural responses to anthropogenic factors, making it paramount to revisit and observe, in real time, the changes exhibited by lion-tailed macaque individuals and troops, as they undergo a pivotal shift in their behavioural-ecological paradigms.

This thesis, thus, attempts to document the ecological changes and behavioural adaptations of a unique lion-tailed macaque population on the Valparai plateau, as it becomes increasingly habituated to humans, and identify key drivers of change that could potentially have major conservation implications for this population. In particular, I document the population demography, using absolute troop counts at pre-determined intervals; habitat-use and movement patterns, using GPS mapping; and behavioural adaptations in terms of time-activity budgets, foraging patterns and social interactions, using standardised focal animal and instantaneous scan observations, of my study population; and attempt an exploration of human–lion-tailed macaque relationships through a day-in-the-life description of the study population as it interacts with local human communities.

While many studies have examined the behavioural variation displayed by species in response to human-modified landscapes, there is, still, little known about the ability of individuals of particular primate species to alter their behaviour and adopt novel strategies in order to take advantage of a given environmental situation. Additionally, very few studies have attempted to evaluate the effects of direct interactions with humans on the socioecology of primate groups. There also appears to be a significant lack of studies that have quantified varying degrees of human influence and elaborated on the nature of human–primate interactions and examined their influences on the shifting ecology and behaviour of the nonhuman species involved.

The principal goals of this study, therefore, were to uncover the demographic, ecological and behavioural responses of select lion-tailed macaque groups that are increasingly utilising the anthropogenic landscape surrounding their rainforest habitats on the Valparai Plateau and initiate long-term monitoring of the macaque subpopulation of the Puthuthottam rainforest fragment. The plateau is a landscape that has experienced large-scale expansion of tea and coffee plantations, and extensive clear felling over the last century. With the increasing fragmentation of its rainforests, thus, Valparai is likely to provide an important model system to understand how currently threatened rainforest primate species respond to the loss and fragmentation of their natural habitats and increasing interactions with local human communities. The specific objectives of this study thus included:

1. Gaining insights into the status of the lion-tailed macaque subpopulation of the Puthuthottam rainforest fragment on the Valparai plateau by documenting certain demographic factors, such as troop numbers, sizes and age/sex compositions, and estimating the birth- and mortality rates of adults and infants the study troops of this subpopulation

2. Investigating the habitat use of and competition for resources across the multiple lion-tailed macaque troops, residing in the Puthuthottam forest fragment, through analyses of their ranging and movement behaviour

3. Examining the adaptability of the study lion-tailed macaque troops that frequent human habitations by investigating the behavioural variations, exhibited by them during foraging and their social interactions, both within and across interacting troops

4. Uncovering varied perceptions of people towards house-raiding macaques, based on the frequency of their visits, history of the relationship with the macaques, amount of food resources available for the macaques and potential economic and other losses to the people

During this study, we established the current population status – including the structure and composition of the constituent troops – of the Puthuthottam subpopulation of the macaques, adding to years of historic data, and investigated key demographic parameters of these troops in relation to other demographic features of the population. We focused particularly on birth rates, as they directly influence the overall fitness and survivability of a population. Using absolute group counts, we recorded group compositions at six-monthly intervals over a period of three years, from January 2018 to July 2020. Not surprisingly and possibly due to their increasing dependence on anthropogenic food resources, we found an increase in the overall population size and number of troops present in Puthuthottam over the span of a decade. Unlike previous observations, however, we found most troops to be primarily comprised of infants and juveniles – with these age categories also showing the most fluctuations between troop counts, indicating their relatively high mortality rates. Our study also revealed a drastically reduced population growth rate and moderately reduced birth rates, when compared to previous estimates. Anthropogenic causes contributed to most deaths in Puthuthottam and occurred primarily on the main road or within the Human Settlement habitat, one of the four habitats investigated during this study. Exponentially growing populations are expected to eventually reach a carrying capacity and undergo a plateauing followed by a potential crash, a trend which is further exacerbated by habitat fragmentation. We believe that the Puthuthottam population is indeed experiencing a steadying in growth rate, an evaluation that could be invaluable in the future management of the species in this landscape.

We also examined the ranging and movement patterns of each of the five troops, residing in Puthuthottam, through an assessment of the changes in homerange sizes as the troops increasingly explored human habitations, in real-time. We recorded the movements of each troop using a GPS device, at intervals of 15 minutes, and later mapped these location data to conduct spatiotemporal analyses of their ranging patterns. We found that troops visited the highway, which divides the Puthuthottam fragment, at varied rates, with the largest troop visiting it most frequently. The overall visitation rate to human habitations was also observed to have increased over the last two decades. All the Puthuthottam troops incorporated human settlements into their core- and outer-homeranges, with three troops ranging largely in the

southern half and two troop ranging only in the northern half of the fragment, with their adjoining human habitations. While all the troops showed a drastically reduced homerange size, as compared to those exhibited by wild lion-tailed macaque populations, we believe the ability of the troops to sustain themselves within these small ranges was largely aided by the presence of easily accessible human-origin foods. We used overlap in homeranges as a proxy measure to evaluate inter-group competition and found potential evidence for scramble competition, with relatively low range overlap, despite the very limited space available to the troops. Finally, comparative analyses for a preference for particular habitats revealed that all the study troops used human-altered habitats, such as the road or human settlements, disproportionately more than their respective areas, suggesting an increasing dependence on anthropogenic foods of the members of the Puthuthottam subpopulation. This, we believe, is a crucial finding that will help our further understanding of the behavioural ecology of this originally rainforest-adapted macaque population in the human-modified landscapes of the future.

We then focussed on three of the five Puthuthottam lion-tailed macaque troops to document their foraging behaviours and intra-troop social interactions through focal animal sampling and group scan sampling. We examined differences in time-activity budgets across these three troops with varying degrees of habituation, and variation in foraging frequencies as well as in inter- and intra-group social interactions, as the troops traversed across the four distinct habitats, referred to above, which varied significantly along a human-influence gradient. We observed the time-activity budgets to vary significantly between troops with different levels of human habituation, with the relatively more habituated troops being terrestrial for a majority of their time, engaging less in Food Search behaviours, as they had easy access to clumped human-use foods and exhibiting frequent intra-troop social interactions. A specific comparison across two particular troops – one that spent most of its time in the Human Settlement habitat and the other relatively more time in the Forest Interior habitat – revealed that the former displayed increased rates of intra-group aggression, possibly as a result of the heightened competition over human-origin food resources. In the study troop that traversed over all the four study habitats, allogrooming reciprocity, a measure of equitable allogrooming in a troop, and thus, its cohesive strength, seemed to break-down in human-modified habitats, with subordinate individuals preferentially allogrooming certain dominant individuals, conceivably as a means of ensuring first access to resources. This theory is supported by our finding that subordinate individuals tended to forage at much higher frequencies than did dominant

individuals, perhaps as compensation for delayed access to attractive foods. Many of our observations are also similar to those observed in primate species, residing in human-dominated landscapes from across the globe. A common belief so far has, however, been that the lion-tailed macaque, a habitat-specialist species, would not be able to adapt well to rapidly changing, anthropogenic environments. We, however, show, in this study, that the species does possess remarkable adaptive potentialities that are indeed exhibited to a great extent as well. Nevertheless, under current situations of ever-increasing habitat alterations, it would become crucial to aid in the species' conservation and management by first, increasing habitat connectivity for the long-term survival of these species populations and second, examining the long-term risks posed to these groups and individuals of becoming completely habituated to humans and excessively dependent on human-origin food resources.

The findings from this study, thus, suggest that the study lion-tailed macaque population exhibits classic signs of synurbisation, particularly in its habitat selection and foraging patterns. The population thus makes disproportionate use of select human-origin habitats, wherein they have discovered a novel and precious food resource – garbage – spending, as a result, relatively less time on foraging while increasingly engaging in other activities, including resting and social interactions. Access to human-use foods, however, presents a two-fold challenge: (1) the need to move over human-made structures, such as roads or buildings, leading to increased mortality risks, and (2) heightened competitive inter-individual interactions, leading to inter-troop scramble competition and temporal shifts in intra-troop social relationships. The study individuals and troops, nevertheless, have varied responses to these anthropogenic factors, perhaps determining the differential long-term survival potentialities of this vulnerable macaque population. The local human communities, in general, resent the presence and activities of the lion-tailed macaque troops, which often leads to costly structural damages to their homes and gardens, but seem to take pride in sharing space with them, especially when educated about the behavioural complexities and the uniqueness of the species. We sincerely hope that this thesis, in addition to providing novel and crucial insights into the adaptive abilities of an unusual rainforest primate species, will ultimately inform the local conservation management for the long-term survival of one of its unique, though threatened, populations in the future.